

A METHOD FOR THE LONG-TERM PRESERVATION OF MEAT
AND THE MEAT PROCESS THEREBY

BACKGROUND OF THE INVENTION

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TECHNICAL FIELD

The present invention relates to a method
for preserving raw meat and more specifically
relates to a method for preserving raw meat by
10 exposing the meat to an atmosphere consisting
essentially of carbon monoxide.

BACKGROUND ART

It is well known in the meat processing
15 industry that from the time animals are
slaughtered, measures must be taken to preserve the
meat and prevent it from becoming rancid or
spoiled. The measures to preserve raw meat must be
implemented and carried through from the time the
20 animal is first slaughtered through the time the
meat is purchased and ultimately consumed by the
purchaser.

Historically, preservation of the
freshness or quality of the meats has been
25 practiced for hundreds, if not thousands of years.
Early preservation techniques of meat took the form
of drying or "jerking" meat and packing or storing

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cuts of meat in salt. This method, while somewhat effective for preserving meat and keeping it from becoming spoiled, had many drawbacks not the least of which was the incorporation of large amounts of salt into meat slated for human consumption.

The use of additives or preservatives such as nitrates and nitrites to meats is another common technique for preserving meat over time. However, there is ever increasing evidence that such additives may have harmful, even carcinogenic drawbacks. These drawbacks detract from the use of these compounds as mechanisms for the long term preservation of meat.

With the introduction of reliable means for refrigeration, i.e., the ability to maintain a low temperature regardless of the external environment, the long-term preservation of raw meat has been greatly enhanced and greatly increased the duration of the preservation. Frequently, in modern meat processing, animals are slaughtered at one place which can be remote from the point of sale and the eventual consumer, and as much as a week can pass before the meat is actually consumed. This lag between the slaughtering of the meat and its consumption requires that the meat be constantly maintained under refrigeration in order

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to preserve its quality and prevent its degradation over this time period.

For example, an animal (a cow) may be slaughtered and cut into halves or quarters which
5 are then forwarded to a wholesaler or retailer where they may be divided into smaller cuts such as steaks or roasts. During the transfer of the meat from the slaughter house to the wholesaler or retailer, the meat must be maintained, frequently
10 the meat is frozen in order to preserve its quality. After the meat has been divided into cuts for sale to the eventual consumer, it must also be maintained under constant refrigeration in order to preserve its quality. Under this distribution
15 scheme, it can be from a few days to more than a week before the meat is purchased and consumed. It, therefore, becomes evident that this constant requirement for very low temperatures greatly contributes to the cost of meat.

20 Another example of the costly disadvantages of very low transportation and storage temperatures can be illustrated by practice of long distance overseas shipment and distribution of frozen meat. Today, freezing is a standard
25 method of distributing meat processed in one region of the world to another region where it is to be

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consumed. Overseas shipment of frozen meat is both very costly and thawed meat obtained by this method is no longer considered to be "fresh" meat. That is, once a piece of meat has been frozen, by definition it is no longer considered to be "fresh." A method of overseas transportation of meat which maintains the "freshness" of meat transported for distribution would be highly desirable. Since the only method available for long distance overseas distribution of meat is by shipping frozen meat, no method currently exists which would allow for the overseas distribution of "fresh," unfrozen meat.

Transportation of slaughtered meat from the slaughter house to the wholesaler or retailer requires the use of some form of refrigerated transportation, such as refrigerated tractor-trailer trucks. This is a costly mode of transportation since it requires specialized equipment and extra fuel to provide and maintain refrigeration.

5 methods have been developed which maintained for
example, the red color of fresh meat, such as beef.

Both of the Hood references disclose methods of exposing an animal protein source to a reducing agent and then an environment of carbon monoxide in order to preserve the bright red color of protein source. Additionally, the Hood et al. references only treat slurries of the protein source as this is required for saturation by the carbon monoxide. The source is then mixed with the remainder of the food stuff to prepare a moist dog food. Further, the references are concerned only with the application of carbon monoxide in order to preserve the color of product and both require

subsequent processing, such as canning or heat sterilization, in order to preserve the actual quality and freshness of the product.

5 Additionally, the Hood '983 reference discloses the addition of a sufficient amount of microbiological and bacteriological inhibitors to further preserve the product.

10 The Woodruff et al. '835 reference discloses a process for maintaining a good color and the freshness meat by first exposing meat to an atmosphere with a small amount of oxygen and then exposing the meat to a modified atmosphere containing a small amount of carbon monoxide to effect the conversion of myoglobin to
15 carboxymyoglobin. A third required step is the maintenance of the meat in an atmosphere of higher than 10% carbon dioxide.

20 The Woodruff et al. '040 patent discloses a process for storing or shipping fresh meat in a modified gaseous atmosphere. The process requires maintaining refrigerated meat in an artificial atmosphere composed of oxygen, carbon dioxide and carbon monoxide as well as nitrogen. The carbon monoxide may be removed from the modified material
25 after the meat has been treated for at least one hour.

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The Koch et al. '117 patent discloses a cover useful for treating fresh red meat with carbon monoxide in order to maintain the bright red color of the meat. Koch et al., teaches a cover
5 comprised of two films which are sealed together around the edges and which confines a quantity of carbon monoxide gas therebetween. Both film layers are substantially carbon monoxide impermeable when dry, however; when the film is brought into contact
10 with a freshly cut sample of red meat, the moisture in the meat wets the film and transforms the film into a carbon monoxide permeable structure. The carbon monoxide then contacts the meat sample thereby causing the meat to maintain its desired
15 red color.

The Australian Patent Document No. AU-A-18559/92 to Tamayama et al., discloses a method for maintaining and improving the quality of meat by causing meat to contact and absorb carbon
20 monoxide gas in a sealed container and then requiring removal of the carbon monoxide gas from the container. Exemplifying the criticality of the removal of the carbon monoxide gas from the container, the patent requires that the carbon
25 monoxide gas within the container be sucked and discharge by means of a pump.

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Heretofore, the treatment of raw meat with carbon monoxide has been taught simply as a mechanism for preserving the color of the meat and, not as a mechanism for the long-term preservation of a meat sample over time in a fresh, non-frozen form.

While the above-disclosed patents teach the exposure of raw meat to gas mixtures containing carbon monoxide or the exposure of meat slurries to carbon monoxide in combination with other steps, they fail to teach a simple method of exposing raw meat solely to carbon monoxide.

In order to overcome the problems and deficiencies of the prior art methods, it is desirable that a method of preserving raw meat be introduced which eliminates the cost and associated problems with the prior art preservation techniques.

Applicant has developed a single step method for preserving meat by exposing raw meat to an atmosphere consisting essentially of carbon monoxide and, then, storing the meat in a sealed container. Unlike prior art preservation methods, no additional steps, compounds or additives are required in order to prevent the growth of microbiological or bacterial organisms.

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SUMMARY OF THE INVENTION AND ADVANTAGES

According to the present invention, a method for preserving meat by exposing raw meat to an atmosphere consisting essentially of carbon monoxide is shown. Meat treated according to the present invention may not require any form of subsequent refrigeration under certain conditions and time constraints and can be stored for long periods of time following treatment with the carbon monoxide without significant bacterial growth, without freezing, and without a loss in meat quality.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

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FIGURE 1 is a bar graph of the relationship between aerobic bacterial growth on a fresh meat sample stored at 22-30°C over time in either a CO treated environment or an air only environment;

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FIGURE 2a is a histogram illustrating preservation duration of CO preserved meats and air treated meat preserved at $5 \pm 3^{\circ}\text{C}$ as determined by Microaerophil growth;

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FIGURE 2b is a histogram illustrating preservation duration of CO preserved meats and air treated meat preserved at $5 \pm 3^{\circ}\text{C}$ as determined by total viable aerobic bacterial growth;

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FIGURE 3 is a graph illustrating spectral analysis of the amounts of hemoglobin in the blood of cats that consumed either CO treated meat or air treated meat;

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FIGURE 4 is a photograph illustrating meats, the colors of meat treated with (A) vacuum only, (B) N_2 , (C) air, and (D) CO;

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FIGURE 5 is a photograph illustrating the color change in meat treated without CO (left) and meat treated with CO (right);

FIGURE 6 is a photograph illustrating the internal color change of meat treated without CO (left) and meat treated with CO (right);

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FIGURE 8 is a photograph illustrating the same meat sample shown in Figure 7 stored with CO at 5°C for ten days;

FIGURE 10 is a photograph illustrating
15 transverse cuts of CO treated (left) and frozen
(right) meat samples after twelve days of storage;

FIGURE 11 is a photograph of the transverse cuts of meat shown in FIGURE 10 after cooking;

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FIGURE 13 is a photograph illustrating a section of CO ^{in A4} treated meat as shown in FIGURE 10, following exposure to open air at 5°C for two weeks, at the end of this two week period, the meat sample was ground, a 200 gram "hamburger-like" sample was cooked and released CO was measured, (top) prior to cooking, (bottom) following cooking.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

10 Generally, the present invention provides a method for preserving meat by exposing raw meat, processed or not, to an atmosphere consisting essentially of carbon monoxide (CO) and, subsequently, storing the meat in a sealed
15 container.

^{in A5} For the purposes of the present invention, the term "meat" is defined to include all types of fresh meat and fresh poultry such as beef, pork, veal, lamb, chicken, turkey, fish and
20 the like. The meat may be in the form of carcasses, primals (e.g., quarters), subprimals (e.g., top round), or retail cuts (e.g., steaks, ground meat and roasts). The process is also effective on whole animals including, but not
25 limited to, cattle, chickens, and fish. Unlike prior art methods, the meat need not be slurried or

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otherwise pretreated. "Fresh meat" is defined as a meat article which has not been frozen and subsequently thawed before its sale or consumption.

By preserving, it is meant that the meat
5 maintains a pleasing color, does not spoil and develop a foul smell, bacterial growth is significantly inhibited or retarded, and remains completely pleasing, edible and consumable by humans and other animals. Preservation is not only
10 maintained on the surface of the meat, but also throughout the entirety of the meat. That is, the meat is preserved throughout the thickness of the meat. "Pleasing color" implies that the color of the meat, preserved by the method according to the
15 present invention, is such that it stimulates the appetite to consume the meat. That is, the color and odor of the preserved meat is such that a consumer would be enticed by the meat and would want to consume the meat. Again, meat color is
20 also preserved throughout the thickness of the meat.

The term "without freezing" is defined as storing the meat wherein the temperature is kept between approximately -2 to 30°C. The term
25 "without freezing" also excludes the use of any device or method for freezing the meat. Such

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devices include, mechanical or electrical refrigeration devices such as refrigerators, freezers, coolers, and chillers. This term also excludes the preservation of meat by freezing
5 through storage on ice.

See A6 Exposing raw meat to an atmosphere consisting essentially of carbon monoxide is defined as bringing into intimate contact both carbon monoxide gas and the meat being treated.

10 The atmosphere preferably consists of carbon monoxide. This term also includes the complete conversion of myoglobin present in the meat sample to carboxymyoglobin and, the complete conversion of myoglobin to carboxymyoglobin/carboxyhemoglobin in
15 fish. The meat is completely immersed or saturated with carbon monoxide.

More specifically, a cross-section of meat is completely immersed in or saturated to its core with carbon monoxide from the exposed surfaces
20 through the entire cross-section (thickness) including its core region and retains the carbon monoxide until the meat is cooked. Thus, as stated above, the meat is preserved throughout its thickness.

Carbon monoxide is inherently a very inert gas. Carbon monoxide is relatively more inert than nitric oxide gas (NO) released from nitrites which have been used as preservatives for meat for several hundred years. Carbon monoxide is a normal metabolite in the body. It is produced indigenously as a product of heme catabolism (mostly the breakdown of hemoglobin). Carbon monoxide is further converted to carbon dioxide and is released from the body in that form. Recently, it has been found that normal metabolism utilizes carbon monoxide as a neurological messenger. (Baranaga, 1993) The high toxicity of carbon monoxide generally stems from its ability to compete with oxygen for binding to hemoglobin.

Practically all of the carbon monoxide (over 99.9%) taken up by meat will be maintained as hemoglobin and myoglobin (Hb/Mb) bound forms. The distribution of carbon monoxide in the meat is assumed to be about half in each globin type. This estimation is based on the fact that mammalian muscles contain approximately two-thirds of their globins as hemoglobin and one-third as myoglobin, but when muscle becomes packed as meat, it loses a portion of its hemoglobin.

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oxidations. Unlike the case of oxygen bound to Hb/Mb, in a carbon monoxide bound form, Hb/Mb are protected from autooxidation. Therefore, to protect meats from autooxidation, carbon monoxide
5 is best applied to fresh meat.

It is thought that the mechanism for carbon monoxide preserving of meat is the much greater affinity of myoglobin for carbon monoxide than for oxygen. Following this mechanism, carbon
10 monoxide out-competes oxygen for binding onto myoglobin molecules within the meat structure. By completely displacing oxygen, the micro-environment of the meat becomes more anaerobic and, thereby, prevents or inhibits the growth of aerobic
15 microorganisms, such as *Escherichia coli*, which are responsible for spoilage and degradation of fresh meat and illness. Anaerobic bacterial growth, such as *Microaerophils*, is also inhibited when this method is utilized. This proposed mechanism of
20 carbon monoxide action is merely for illustrative purposes and in no way should be construed as limiting.

The ability to inhibit or prevent the growth of microorganisms allows for the extended storage of meat treated according to the present method. That is, meats treated according to the
5 present invention have a longer storage life and remain both viable and edible in a non-contaminated form for periods longer than those available using current preservation techniques.

In the practice of the present invention,
10 meat samples are placed in an enclosure or container and flushed or exposed to carbon monoxide gas.

The process consists of two stages:

(A) "Meat packing" which refers to
15 introducing the meat into a confined CO atmosphere. "Packed meat" refers to meat which has undergone the meat packing part of the process.

(B) "Meat preservation" which involves
20 maintaining the "packed meat" until it reaches the consumer.

Meat Packing

The container for treatment, storage, and transportation of meat by the method of the present
25 invention can be constructed of various gas-impermeable material such as plastic, metal, and

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other materials known in the art. The container can be equipped with both gas inlet and outlet channels which can be opened to allow the influx of gas (CO) or closed in order to render the container
5 sealed.

A suitable container would be capable of maintaining a seal to prevent the escape of carbon monoxide gas from the container. For example, the container can be a sealed room in which large
10 amounts of meat may be treated at a given time, the container can also be a smaller sealable container or chamber. Preferably, the container is of larger volume than the volume of meat being treated to allow for a greater volume of carbon monoxide gas
15 to contact the meat sample.

In a preferred embodiment of the invention, meat samples are treated and stored within plastic bags constructed of a material which is safe for the storage of food products such as
20 polyvinylidene chloride. Preferably, the plastic bags will be constructed of a material that is impermeable to the passage of gases therethrough. Thusly, the meat is maintained in the carbon monoxide atmosphere within the bag (container)
25 during storage.

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After a piece of meat to be treated according to the method of the present invention is placed in a suitable container, the container is then filled with the CO gas. The addition of the
5 CO gas can be accomplished in any suitable manner; however, the preferred methods include first removing the gas atmosphere present in the container (usually air) by using a vacuum pump, as is well known in the art, to remove any gases
10 present and the container. The container is then filled with CO from a source such as a gas cylinder.

The container is connected to the CO containing cylinder and CO is introduced. Input
15 and output pressures are measured during the filling process. The input pressure is generally maintained within a range of approximately 1.5 to 5.0 atmospheres. The preferred pressure is approximately 2.0 atmospheres. Upon reaching the
20 preferred pressure in the output, the gas flow is stopped and excess gas is allowed to escape until the pressure within the container reaches approximately 1.0 to 1.2 atmospheres. The preferred gas pressure in the container is
25 approximately 1.1 atmospheres.

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During the gas filling operation, the ambient temperature of the surrounding can be maintained between -2 to 37°C.

The parameters that govern gas filling or exposure time vary depending on the pressure of the gas input, the dimensions of the inlet and outlet channels, and the dimensions of the container.

For meat packing, exposure of only the surfaces of the meat to carbon monoxide is generally required. However, for the purposes of meat preservation, the gas filling time should be long enough to allow for a sufficient amount of CO gas to be completely absorbed (throughout its thickness) into the meat undergoing treatment. That is, enough CO gas is flushed through the container to allow for the complete penetration and protection of the meat being treated.

The gas filling time generally ranges from approximately one to thirty minutes with the preferred filling time being approximately five minutes. For the purposes of this invention, exposure time is defined as the gas filling time. Again, it should be noted that the length of exposure of the carbon monoxide to a meat sample will vary depending on the size of the meat sample and the weight of the meat sample being treated.

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That is, a larger and heavier meat sample will require a longer period of exposure to the carbon monoxide in order to achieve long-term preservation. In other words, a larger meat sample
5 will require a longer exposure to carbon monoxide in order to properly preserve the meat sample without the freezing.

The temperature during the carbon monoxide exposure is preferably between -2 and 37°C
10 and can vary depending on the temperature selected to in order to carry out the method.

Meat treated as previously described above generally contains from 5 to 100% by weight or volume of CO gas. The preferred volume of CO in
15 the treated meat is approximately 30% of the weight of the meat (e.g. 30 ml for 100 grams of treated meat).

Under the meat preservation method of the present invention, the meat surface is initially
20 contacted with the CO gas. Since the surface of the meat is the most prominent site for the presence of bacteria, the meat treated by the method of the present invention is immediately protected. Further, while sealed in the container,
25 penetration of the CO gas continues until the entire meat mass has been penetrated and, thereby,

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protected. This total penetration allows for the complete substitution of both hemoglobin and myoglobin by the carboxy forms of these compounds as is shown in the following examples. The total
5 CO treatment of the meat throughout its thickness also enables meat which has been treated according to the present invention to maintain a pleasing color for extended periods of time after the meat has been removed from the packaging or container in
10 which it was treated. That is, as shown in the following examples, meat treated according to the present invention can be transported, unpacked, and then maintained in a fresh form for a further extended period of time without a loss of color or
15 quality.

The above discussion provides a factual basis for the use of the present invention as a method of long-term preservation of meat at different temperatures without freezing. The
20 examples also demonstrate the preservation of the meat after undergoing the treatment of the present invention. The methods used with and the utility of the present invention can be shown by the following examples.

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